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LHC Interaction Region Quadrupole Cryostat Heat Exchanger Test Module Specification

Fermilab Specification: 5520-ES-364156

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None	June 22, 1998	Original issue	T. Nicol	T. Nicol
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1.0 Scope.

- 1.1 This specification defines the requirements for four identical cryogenic vessels to be delivered to Fermilab for subsequent use at CERN in Geneva, Switzerland. These modules will be used to test the performance of a 1.8K heat exchanger identical to one proposed for incorporation in cryostats being developed by Fermilab for installation in the Large Hadron Collider (LHC) interaction regions at CERN.

Each of the modules must be designed and constructed to comply with the requirements of the latest version of Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code and must be code-stamped to verify that compliance.

The module assembly is shown in Fermilab drawing 5520-ME-364057.

2.0 General module description.

- 2.1 Each of the four modules being fabricated are identical to one another and will be assembled in series into a string approximately 30 meters long. One end will be attached to a cryogenic feed box, the other to a turnaround module. Neither the feed box nor the turnaround module are subjects of this specification.
- 2.2 The modules include an external vacuum vessel, a low temperature helium shield, and an internal helium piping assembly. Support structures for the internal piping and shields and several blankets of multi-layer insulation serve to limit heat conduction from the surrounding environment to the helium systems. Temperature and pressure measurement instrumentation and internal heaters serve to support the testing required to verify the performance of the heat exchanger.
- 2.3 Length and diameter dimensions shown on 5520-ME-364057 and all constituent subassembly drawings must be maintained. Materials, tube and pipe wall thicknesses, flange thicknesses, and weld dimensions must be verified by the module manufacturer to ensure compliance with pressure vessel code requirements.

3.0 Outer vacuum vessel design requirements.

- 3.1 The outer vacuum vessel, flanges, stiffening structures, instrumentation tubes, and vacuum relief assemblies shall be fabricated from type 304 stainless steel. Dimensions are referenced on drawing 5520-ME-364058.
 - 3.2 Although the outer vacuum vessel is not required to be a code compliant vessel, it must be designed and manufactured to the rules and recommended practices of the latest version of the ASME Code, Section VIII, Division 1 for vacuum vessels.
 - 3.3 The outer vessel shall be capable of withstanding full internal vacuum with one atmosphere pressure on the outside with a safety factor of two.
 - 3.4 Copies of any and all material certifications and material test results must be supplied with all assemblies.
- 4.0 Low temperature shield design requirements.
- 4.1 The low temperature shield shall be fabricated from aluminum sheet and 304L or 316L stainless steel tube. Dimensions are referenced on drawing 5520-MD-364054 and 5520-MD-364131. Refer to section 5.0 for additional requirements on the shield tube assemblies.
 - 4.2 All supports for the low temperature shield pipes must allow free expansion and contraction where necessary.
 - 4.3 The low temperature shield shall be insulated using 30 layer-pairs of multi-layer insulation (MLI) consisting of alternating layers of reflective mylar and spacer material. Dimensions and materials are referenced on drawing 5520-MB-364087.
 - 4.4 Copies of any and all material certifications and material test results must be supplied with all assemblies.

5.0 Internal piping design requirements.

- 5.1 All internal piping material shall be 304L or 316L series stainless steel and shall be formed from continuous lengths of pipe or tube to the maximum extent practical. Joints shall be welded in a manner consistent with applicable codes. Dimensions are referenced on drawing 5520-ME-364049 and all constituent subassembly drawings.
- 5.2 The corrugated copper tube used inside the heat exchanger assembly will be supplied by Fermilab. Dimensions are referenced on drawing 5520-MC-364063.
- 5.3 All supports for the internal pipes must allow free expansion and contraction where necessary.
- 5.4 The following table summarizes the operating requirements for the internal piping.

Description	Fluid	Temperature Range	Internal Pressure Range	External Pressure Range
Magnet pipe	LHe	300K to 1.8K	Vacuum to 20 Bars	Vacuum to 1 Bars
Heat exchanger external pipe	LHe	300K to 1.8K	Vacuum to 20 Bars	Vacuum to 1 Bars
Heat exchanger internal corrugated tube	LHe and GHe	300K to 1.8K	Vacuum to 20 Bars	Vacuum to 20 Bars
LHe supply	LHe	300K to 1.8K	Vacuum to 20 Bars	Vacuum to 1 Bars
Cooldown return	LHe and GHe	300K to 1.8K	Vacuum to 20 Bars	Vacuum to 1 Bars
Low temperature shield	LHe and GHe	300K to 4.5K	Vacuum to 20 Bars	Vacuum to 1 Bars

6.0 Bellows.

- 6.1 All of the internal piping and the external vacuum vessel will be joined to adjacent modules using stainless steel bellows. Fermilab will supply the external vacuum bellows to the module vendor. All other bellows will be supplied by Fermilab to CERN and are not part of this fabrication or specification.

7.0 Instrumentation.

- 7.1 Instrumentation is provided to measure the temperature and pressure of all of the cryostat systems at operating conditions as well as to provide heat input for calibration and measurement. These devices, their associated wiring, and external connectors are fragile and prone to failure if mishandled, improperly protected from heat or high electrical currents, especially during welding. Care must be exercised at all times and sufficient checks must be incorporated into the assembly processes to ensure the operational integrity of these devices.

8.0 Safety relief devices.

- 8.1 All safety relief devices will be supplied by Fermilab and are not part of this specification.

9.0 Testing and documentation.

- 9.1 Piping shall be pneumatically testing at 125% of the maximum allowable working pressure (MAWP). All joints, including safety device inlet connections, shall be soap bubble checked for leakage at the test pressure.

- 9.2 The following tests shall be performed with the insulating vacuum connected to a leak detector with a minimum sensitivity of 2×10^{-9} torr-liter/sec of helium.

- 9.2.1 All joints on the outside of the vacuum vessel shall be sprayed with helium with no detectable leak.

- 9.2.2 The internal helium piping systems shall be pneumatically pressurized to 125% of their MAWP with helium with no detectable leak.

- 9.3 The manufacturer shall furnish all code UA-1 forms and certificates of mass spectrometer and piping tests.

10.0 On-site inspections by Fermilab.

- 10.1 Fermilab reserves the right to make on-site inspections of the module components and assembly during manufacturing. In particular, Fermilab would like to inspect the internal piping prior to wrapping with MLI and the instrumentation assemblies prior to welding them in place.

11.0 Fermilab supplied material.

- 11.1 Calibrated thermometers mounted on circuit boards with wires attached will be supplied by Fermilab for installation into the internal piping. We will also supply the heater assemblies for mounting into the magnet pipe and all room temperature electrical connectors for connection to the instrumentation and heaters.
- 11.2 Fermilab will supply parallel plate vacuum relief assemblies for welding to the vacuum vessel assembly.
- 12.0 Cleaning and packaging.
 - 12.1 All dewar components must be free of grease, residue, dirt, and chips and packaged such as to ensure delivery in a clean condition.
 - 12.2 The vendor is responsible for shipment of all modules from their point of manufacture to Fermilab. Fermilab in turn will handle shipping to CERN. However, the vendor shall provide a shipping container for each module compatible with the need to ship from their facility to Fermilab by truck and/or rail and from Fermilab to CERN by ocean going transport.
- 13.0 Warranty.
 - 13.1 The manufacturer will warrant all materials and workmanship for a period of 18 months from shipment. The only exceptions will be items supplied by Fermilab.